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Bescheinigung | Certificate | Attestation

4

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. Patent application No. Demande de brevet n°

98310768.1

PRIORITY DOCUMENT

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Der Präsident des Europäischen Patentamts;
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Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

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The original title of the application reads as follows:
Reactor

TS 0743 EPC
Haz

REACTOR

The present invention relates to a reactor wherein the available area of the upstream surface of the catalyst bed can be regulated, to the use of such a reactor in a process for the catalytic conversion of a feed mixture which is capable of ignition or explosion, in particular a catalytic partial oxidation process, and to transport means provided with the reactor.

The partial oxidation of hydrocarbonaceous feedstocks, in particular hydrocarbons, in the presence of a catalyst is an attractive route for the preparation of mixtures of carbon monoxide and hydrogen, normally referred to as synthesis gas. The partial oxidation of paraffinic hydrocarbons is an exothermic reaction represented by the equation:

$$C_nH_{2n+2} + n/2\ O_2 \rightarrow n\ CO + (n+1)\ H_2$$

There is literature in abundance on the catalysts and the process conditions for the catalytic partial oxidation of gaseous hydrocarbons, in particular methane. Reference is made, for instance, to EP-A-303 438, US-A-5,149,464, and International patent application WO 92/11199. For successful operation at a commercial scale, the catalytic partial oxidation process must be able to achieve a high conversion of the hydrocarbon feedstock at very high throughputs. In the art, the catalytic partial oxidation of gaseous hydrocarbons at a gas hourly space velocity in the order of 1,000,000 Nl/kg/h or more is known, for example from US-A-5,648,582.

Recently, also the catalytic partial oxidation of liquid hydrocarbons and oxygenates at very high throughputs has been described in European patent application No. EP 97308154.0 (filed 14 October 1997).

The hydrogen produced by the catalytic partial oxidation process of hydrocarbonaceous feedstocks, in particular liquid hydrocarbons, can suitably be used as feed for a fuel cell. In fuel cells, hydrogen and oxygen are converted into electricity and water. Fuel cell technology is well known in the art.

One of the most challenging applications of fuel cells is in transportation. Vehicles powered by fuel cells are under development. The oxygen needed for the fuel cell may be obtained from the ambient air, the hydrogen feed could be obtained from a hydrogen fuel tank but is preferably produced on-board, for example by catalytic reforming of methanol. The on-board production of hydrogen by catalytic reforming of methanol has been proposed, for example by R.A. Lemons, Journal of Power Sources 29 (1990), p 251-264.

Recently, the on-board production of hydrogen by a catalytic partial oxidation process as described in European patent application No. EP 97308154.0 has been proposed as an alternative for steam reforming of methanol. An important advantage of this catalytic partial oxidation process is its flexibility towards the choice of fuel.

A very important requirement for a power system in transportation applications, is that it must be able to vary the power output with a factor of at least about 60, preferably of at least 100. Several systems for controlling the power output of fuel cell systems for transportation applications are under development. In US 5,771,476, for example, a system for controlling the power output of a fuel cell is disclosed, wherein the

supply of a reactant gas, such as air, to the fuel cell unit is controlled.

Alternatively, in the case of a fuel cell system having an on-board hydrogen-producing unit, the power output may be controlled by regulating the quantity of hydrogen produced. In a catalytic conversion process, the amount of hydrogen produced is directly proportional to the moles of feed mixture that are converted, provided that the composition of the feed mixture is kept constant.

If the supply of feed mixture to a catalyst bed would be varied in the range between the minimum amount desired and up to 60 times that amount, large variations in superficial velocity, residence time, and pressure of the feed mixture would occur. These large variations may result in problems at the highest and lowest feed throughput. Especially in the case of a feed mixture that is capable of explosion or ignition, such as in the catalytic conversion of a mixture of hydrocarbons and an oxygen-containing gas at elevated temperature, the low superficial velocity of the feed mixture at low throughputs could result in a residence time of the feed mixture upstream of the catalyst which is greater than the auto-ignition delay time, thus causing auto-ignition, and in flash-back of flames from the catalyst bed.

Generally, in the prior art, large variations in output are achieved by using a plurality of catalytic reactors, each containing a catalyst provided with a feed supply system, and varying the number of reactors which are turned on, whilst keeping the feed throughput per reactor essentially constant. It will be appreciated that such multi-reactor systems are relatively expensive, since a plurality of feed supply systems, including the flow control equipment, are needed. Moreover, in such a system the output can only be varied stepwise and not

continuously. Therefore, there is a need in the art for catalytic reactors that can achieve large variations in output in one single reactor.

In view of the above, the problem to be solved is how to achieve, in the catalytic conversion of a feed mixture that is capable of explosion or ignition, a large variation in the quantity of conversion products by varying the throughput of the feed mixture, whilst avoiding uncontrolled gas-phase reactions, such as auto-ignition of the feed mixture upstream of the catalyst and flash-back of flames from the catalyst bed.

It has now been found that the above-mentioned problem can be solved by using a reactor wherein the available area of the upstream surface of the catalyst bed can be adjusted as a function of the throughput of feed mixture in such a way that no stagnant zone(s) occur in the fluid in the feed supply chamber. Reference herein to stagnant zone(s) is to zone(s) wherein the fluid is hardly exchanged with fluid from surrounding zone(s), resulting in a relatively long residence time of the fluid in that zone, i.e. relatively long compared to the average residence time of fluid in the feed supply chamber.

Accordingly, the present invention relates to a reactor, suitable for the catalytic conversion of feed mixtures which are capable of explosion or ignition, comprising a feed supply chamber, an effluent discharge chamber, a catalyst bed having (1) an upstream surface and (2) a downstream surface which is in fluid communication with the effluent discharge chamber, and adjusting means for regulating the area of the upstream surface that is in fluid communication with the feed supply chamber, wherein the adjusting means comprise one or more moveable parts defining at least partly the feed supply chamber, in which reactor, during normal

operation, no stagnant zone(s) occur in the fluid in the feed supply chamber. For the purpose of this specification, "the area of the upstream surface that is in fluid communication with the feed supply chamber" will be referred to as "the available upstream surface area".

Reference herein to a catalyst bed is to a permeable fixed arrangement, for example a fixed bed of particles, a porous monolithic structure such as a foam or a honeycomb, or another permeable fixed arrangement, such as arrangements comprising metal gauzes or wires. Alternatively, one single reactor may comprise more than one catalyst bed, for example a plurality of ceramic foams. In the case of a plurality of catalyst beds in a single reactor, reference to the surface of the catalyst bed is to the total surface of all catalyst beds. Feed will be supplied at the upstream side of the catalyst bed, and after catalytic conversion of the feed into effluent, effluent will be discharged at the downstream side of the catalyst bed.

The feed supply chamber is defined as the space upstream of the catalyst bed wherein the reactants are supplied. This space is typically defined by the available upstream surface of the catalyst bed, one or more surfaces of the moveable parts of the adjusting means, and, optionally, by one or more surfaces of non-moveable parts of the reactor.

The adjusting means may be any means capable of regulating the available upstream surface area of the catalyst bed, comprising one or more moveable parts defining at least partly the feed supply chamber. Preferably, the adjusting means comprise one moveable part. Reference herein to moveable parts is to parts capable of rotating, moving up and down or any other type of movement or to flexible parts.

The moveable part(s) typically contain an inner surface directed to the feed supply chamber, thereby defining at least partly the feed supply chamber. "Inner" is defined with respect to the feed supply chamber. Preferably, the moveable part(s) comprise a surface that is or can be directed to the upstream surface of the catalyst bed, thereby capable of covering part of the upstream surface. Typically, the catalyst bed may is non-moveable, but a moveable catalyst bed is possible.

Alternatively, the moveable part(s) may be connected to the catalyst bed in such a way that the available upstream surface area will be regulated by simultaneously moving the catalyst bed and the moveable part. In this case, the upstream surface of the catalyst bed will typically be covered by a non-moveable part of the reactor.

Advantageously, it has been found that the distance between the covered upstream surface of the catalyst bed and the surface covering it (which may be either the inner surface of the adjusting means or the inner surface of a non-moveable part of the reactor) is such that flames cannot be sustained between the two surfaces. Suitably, this distance is not exceeding three times the quenching distance, preferably not exceeding one time the quenching distance. The quenching distance is defined as the distance within which two walls must be brought to prevent flash-back, i.e. flames cannot be sustained at this distance, they are quenched or extinct.

For a given laminar flame velocity and operating pressure, the quenching distance can be calculated by methods known in the art. The laminar flame velocity depends, among others, on the composition and temperature of the feed mixture. Estimation methods for the flame velocity are known in the art. For example, for a catalytic partial oxidation process as described below,

with a oxygen-to-carbon ratio of about 0.5, performed at a pressure of 6 bara, wherein the laminar flame velocity of the feed mixture is about 0.5 m/s, the quenching distance is about 0.5 mm.

The adjusting means suitably consist of inert, high-temperature resistant material, such as metals or refractory oxides. High-alloy, alumina-containing steel, such as fecralloy-type materials are particularly suitable.

Preferably, the shape of the adjusting means is such that it can be partly cooled by the passing feed mixture.

In order to be able to achieve a sufficiently large variation in the quantity of catalytic conversion products, the available upstream area can preferably be varied with a factor of at least 5, more preferable with a factor of at least 10, most preferably of at least 20.

Preferably, the moveable part is a body which is slideably-arranged with respect to the catalyst bed, the body having a first surface directed to the catalyst bed, which first surface is capable of covering at least part of the upstream surface area of the catalyst bed, and a second surface defining at least partly the feed supply chamber. Slideably-arranged means that the body can be slit up and down or rotated, typically in the direction parallel to the upstream surface of the catalyst bed, thereby regulating the available upstream surface area of the catalyst bed.

It will be appreciated that the shape of the feed supply chamber and the position of the catalyst bed relative to the feed supply chamber will determine the direction of the fluid flow at the upstream surface of the catalyst bed. The fluid flow at this point may be perpendicular or non-perpendicular to the upstream surface.

If the fluid flow in the feed supply chamber close to or at the upstream surface of the catalyst bed is not perpendicular to the upstream surface of the catalyst bed, a far end and a near end of the upstream surface of the catalyst bed can be defined with respect to the direction of the flow of the feed mixture.

In the case of a non-perpendicular fluid flow at the upstream surface, the angle between the upstream surface of the catalyst bed and the surface defining the feed supply chamber at the far end is preferably smaller than 70°, more preferably smaller than 60°, an angle smaller than 45° is particularly preferred.

Preferably, the surface defining the feed supply chamber at the near end of the upstream surface of the catalyst bed is substantially parallel to the surface defining the feed supply chamber at the far end. Substantially parallel must be construed as having an angle of not more than 15° with the surface defining the feed supply chamber at the far end, preferably not more than 10°, most preferably an angle of 0°.

The catalyst bed may have any suitable shape. Especially in the case of a non-perpendicular fluid flow at the upstream surface, a catalyst bed in the form of a hollow arrangement having a central longitudinal axis is preferred, more preferably in the form of a hollow cylinder. The hollow arrangement is preferably aligned with the central longitudinal axis of the reactor. The upstream surface of the catalyst bed may be either the inside or the outside of the hollow arrangement, preferably the inside. It will be appreciated that the shape of the slideably-arranged body is to a high degree determined by the shape of the catalyst bed, e.g. in the case of a catalyst bed in the form of a hollow cylinder, the body will be cylindrical.

The slideably-arranged body may be moved with respect to the upstream surface by any suitable means. In the case of a slideably-arranged body positioned at the far end of the upstream surface, the body may be moved by means of the fluid flow.

It will be appreciated that stagnant zone(s) in the feed supply chamber can be avoided during normal operation by regulating the available upstream surface area in such a way that, at any setting of the adjusting means, the shape of the feed supply chamber is such that no dead space(s) occur, thus creating a plug flow regime at any setting of the adjusting means. An additional requirement is that the residence time remains below the auto ignition delay time of the feed mixture.

It has been found that the requirements to the shape of the feed supply chamber, in order to avoid stagnant zone(s), can be somewhat relaxed if, under normal operation, the fluid feed mixture is forced to move in tangential direction.

Thus, the feed supply chamber of the reactor of the invention may be equipped with means capable of swirling a fluid feed mixture in tangential direction, under normal operation. Tangential is defined with respect to the longitudinal axis of the catalyst bed.

The means capable of swirling the feed mixture in tangential direction may be any suitable means, for example a fan, such as the fan of a compressor of a turbocharger. Suitably, the means capable of swirling the feed mixture has a longitudinal axis which is aligned with the longitudinal axis of the reactor.

The invention will now be illustrated in a non-limiting manner with reference to the schematic Figures 1 to 4. The Figures are not drawn to scale.

Figures 1a, 1b, 2a, and 2b each show a cross-section in the plane of the central longitudinal axis through a

part of a reactor in half-opened position having a slideably-arranged body as adjusting means and having, at the far end of the available upstream surface of the catalyst bed an angle of about 20° between the upstream surface and the surface defining the feed supply chamber.

Figure 3a shows a cross-section in the plane of the central longitudinal axis through a part of a reactor wherein the feed supply chamber is equipped with a means of swirling the fluid feed mixture in tangential direction and having a slideably-arranged disc as adjusting means.

Figures 3b and 3c show the slideably-arranged disc of the reactor of figure 3a in opened (Figure 3b) and partly-opened position (Figure 3c).

Figures 1a, 1b, 2a and 2b all show part of a reactor 1 comprising a feed supply chamber 2, an effluent discharge chamber 3, and a hollow cylindrical catalyst bed 4, having an upstream surface 5 and a downstream surface 6. The reactor further comprises a body 7 which is slideably-arranged with respect to the catalyst bed 4, the body having a first surface 8 directed to the catalyst bed and a second surface 9 defining the feed supply chamber 2, and a non-moveable part 10 having a surface 11 which is partly defining the feed supply chamber 2. At the far end of the available upstream surface of the catalyst bed, the angle 12 between the upstream surface 5 and the surface defining the feed supply chamber 2 is about 20°.

In the embodiments of Figures 1a and 1b, the slideably-arranged body 7 is located at the near end of the upstream surface 5. In the embodiments of Figures 2a and 2b, the slideably-arranged body 7 is located at the far end of the upstream surface 5.

In the embodiments of Figures 1a and 2a, the surface defining the feed supply chamber at the near end of the

upstream surface of the catalyst bed (i.e. in figure 1a: the surface 11 of the non-moveable part 10; in figure 2a: the second surface 9 of the body 7) is parallel to the surface defining the feed supply chamber at the far end (i.e. in figure 1a: the second surface 9 of the body 7; in figure 2a: the surface 11 of the non-moveable part 10). In the embodiment of Figures 1b and 2b, the surface defining the feed supply chamber at the near end is aligned with the upstream surface 5 of the catalyst bed 4.

Figure 3a shows part of a reactor 1 comprising three separate catalyst beds 4 (one of the three beds is shown), and means 15 capable of swirling a fluid feed mixture in tangential direction. The adjusting means for regulating the available upstream surface area is a slideably-arranged disc 16 comprising three openings 17 (one of the three openings is shown). In the embodiment of Figure 3a, means 15 is the fan of a compressor of a turbocharger.

Both Figures 3b and 3c separately show the disc 16 comprising three openings 17. During normal operation, the disc is rotating parallel to the upstream surface of the catalyst and is thus capable of regulating the available upstream surface area of the catalyst beds. Figure 3b shows the position of the disc wherein the upstream surface area is maximum. Figure 3c shows the position of disc 16 wherein a large part of the upstream surface area is covered.

It will be appreciated that in the embodiments of the invention according to Figure 1 and 2, the available area of upstream surface of the catalyst bed is, during normal operation, adjusted as a function of throughput of feed mixture in such a manner that essentially no dead space(s) in the feed supply chamber occur.

In the embodiments according to Figure 1 and 2, the shape of the feed supply chamber is such that, during normal operation, at any setting of the adjusting means (i.e. at any value of the available upstream surface area) the fluid is essentially flowing in a plug flow regime, i.e. substantially without occurrence of back mixing.

In order to avoid auto ignition of the feed mixture and flash-back of flames from the catalyst bed in a plug flow regime, it is required that the residence time of the feed mixture in the feed supply chamber is below the auto-ignition delay time and that the superficial velocity of the feed mixture at the upstream catalyst surface is high enough to prevent flash-back.

The feed supply chamber may have a constant volume, i.e. a volume that is not varied as a function of feed throughput, provided that the volume is small enough to warrant that the residence time and the superficial velocity of the feed mixture meets the above requirements at the smallest required feed throughput.

It is preferred that the volume of the feed supply chamber is regulated as a function of the feed throughput. This is the case in the embodiments shown in Figures 1a, 2a, and 2b. More preferably, the volume of the feed supply chamber is regulated in such a way that the residence time of the fluid in the feed supply chamber is varied within a factor of at most 5, upon variations in fluid throughput of a factor 60, and that the superficial velocity is typically kept above 1 m/s for the catalytic partial oxidation process described below.

In a further aspect the present invention relates to a process for the catalytic conversion of a fluid feed mixture which is capable of ignition or explosion, wherein the fluid feed mixture is contacted with a

catalyst bed retained in the reactor as described hereinbefore. In particular, the invention relates to a process for the catalytic oxidation of a hydrocarbonaceous feedstock, wherein a feed mixture comprising a hydrocarbonaceous feedstock and an oxygen-containing gas is contacted with a catalyst bed retained in the reactor as described hereinbefore, at elevated temperature and pressure.

Preferably, the process of the invention is a process for the catalytic partial oxidation of a hydrocarbonaceous feedstock, which process comprises contacting a feed mixture comprising a hydrocarbonaceous feedstock and an oxygen-containing gas, in amounts giving an oxygen-to-carbon ratio in the range of from 0.3 to 0.8, with the catalyst bed at a temperature in the range of from 750 to 1500 °C, at a pressure in the range of from 2 to 100 bara.

The hydrocarbonaceous feedstock suitably comprises hydrocarbons and/or oxygenates which are gaseous under the condition prevailing at the in the catalyst bed during normal operation. The feedstock may contain compounds that are liquid and/or compounds that are gaseous under standard conditions of temperature and pressure (i.e. at 0 °C and 1 atm.).

Particularly suitable feedstocks comprise light hydrocarbons, such as methane, natural gas, and associated gas, or hydrocarbons being gaseous when contacting the catalyst during operation, but being liquid under standard conditions of temperature and pressure. The latter hydrocarbons typically have an average carbon number of at least 6 and contain up to 25 carbon atoms in their molecules, for example hydrocarbons boiling in the range of from 50 °C to 500 °C, preferably in the range of from 60 °C to 350 °C. The term "light hydrocarbons" is a reference to hydro-

carbons having from 1 to 5 carbon atoms. The process is particular suitable for the partial oxidation of kerosene feedstocks boiling between 150 °C and 200 °C or synthetic gas oil feedstocks boiling between 200 °C and 500 °C, in particular between 200 °C and 300 °C.

It is possible to have hydrocarbonaceous material present in the feedstocks which is gaseous under standard conditions of temperature and pressure, together with material which is liquid under standard conditions of temperature and pressure.

The process according to the present invention can also be carried out when the feedstock contains oxygenates (being gaseous and/or being liquid under standard condition of temperature and pressure). Oxygenates to be used as (part of) the feedstock in the process according to the present invention are defined as molecules containing apart from carbon and hydrogen atoms at least 1 oxygen atom which is linked to either one or two carbon atoms or to a carbon atom and a hydrogen atom, such as alcohols, ethers, acids and esters. Examples of suitable oxygenates comprise methanol, ethanol, and dimethyl ether.

Also mixtures of hydrocarbons and oxygenates as defined hereinbefore can be used as feedstock in the process according to the present invention. The feedstock may comprise carbon dioxide.

The oxygen-containing gas may be air, substantially pure oxygen, or oxygen-enriched air. The feed comprises the hydrocarbon and/or oxygenate feedstock and the oxygen-containing gas in amounts sufficient to give an oxygen-to-carbon ratio in the range of from 0.3 to 0.8, preferably of from 0.45 to 0.75, more preferably in the range of from 0.45 to 0.65. References to the oxygen-to-carbon ratio refer to the ratio of oxygen in the form of

molecules (O_2) to carbon atoms present in the hydrocarbon and/or oxygenate feedstock.

The feed mixture may comprise stream and/or carbon dioxide. If steam is present in the feed mixture, the steam-to-carbon ratio (that is the ratio of molecules of steam (H_2O) to carbon atoms in the feedstock) is preferably in the range of from above 0.0 to 3.0, more preferably of from above 0.0 to 2.0.

The catalytic partial oxidation process is preferably operated at a temperature in the range of from 750 to 1500 °C, more preferably in the range of from 800 to 1350 °C. Temperatures in the range of from 850 to 1300 °C are particularly suitable. Reference herein to temperature is to the temperature in the top (i.e. the upstream side) layer of the catalyst bed.

The catalytic partial oxidation process is operated at a pressure in the range of from 2 to 100 bara, preferably in the range of from 3 to 50 bara, more preferably of from 5 to 30 bara.

In the catalytic partial oxidation process of the invention, the feed throughput and thus the gas hourly space velocity (expressed as normal litres of gas per kilogram of catalyst per hour; normal litres are litres at STP, i.e. 0°C and 1 atm.) is varied. At maximum feed throughput, i.e. typically at 0% coverage of the upstream surface of the catalyst bed, the feed mixture is preferably provided at gas hourly space velocities which are in the range of from 50,000 to 10,000,000 Nl/kg/hr, more preferably in the range of from 100,000 to 10,000,000 Nl/kg/hr, even more preferably in the range of from 200,000 to 3,000,000 Nl/kg/hr. Maximum space velocities in the range of from 500,000 to 1,500,000 Nl/kg/hr are particularly suitable.

During the catalytic partial oxidation process, the feedstock and the oxygen-containing gas are preferably

contacted with the catalyst under substantially adiabatic conditions. For the purposes of this specification, the term " substantially adiabatic" is a reference to reaction conditions in which substantially all heat loss and radiation from the reaction zone is prevented, with the exception of heat leaving in the gaseous effluent stream of the reactor.

Catalyst compositions suitable for use in the catalytic partial oxidation process are known in the art. Such catalysts generally comprise, as active component, a metal selected from Group VIII of the Periodic Table of the Elements. References in this specification to the Periodic Table of the Elements are to the CAS version, as published in the CRC Handbook of Chemistry and Physics, 68th Edition. Catalysts comprising, as the catalytically active component, a metal selected from rhodium, iridium, palladium and platinum are preferred. Catalysts comprising rhodium or iridium are most preferred.

The catalytically active metal is most suitably supported on a carrier, such as refractory oxide particles, monolithic structures, or metallic arrangements. Suitable carrier materials are well known in the art and include refractory oxides, such as silica, alumina, titania, zirconia and mixtures thereof. Mixed refractory oxides, that is refractory oxides comprising at least two cations may also be employed as carrier materials for the catalyst.

The catalyst may comprise the catalytically active metal in any suitable amount to achieve the required level of activity. Typically, the catalyst comprises the active metal in an amount in the range of from 0.01 to 20% by weight, preferably from 0.02 to 10% by weight, more preferably from 0.1 to 7.5% by weight.

Hydrogen or a mixture of hydrogen with other gases, prepared by the catalytic partial process of this

invention may be particularly suitable for use as a combustible fuel, either directly or indirectly.

The preferred process is suitably used to prepare hydrogen from any hydrocarbonaceous feedstock, especially for the on-board production of hydrogen in fuel cell powered transport means, such as automotive vehicles and crafts.

Accordingly, the present invention also relates to transport means provided with the reactor of this invention.

C L A I M S

1. A reactor, suitable for the catalytic conversion of feed mixtures which are capable of explosion or ignition, comprising a feed supply chamber, an effluent discharge chamber, a catalyst bed having (1) an upstream surface and (2) a downstream surface which is in fluid communication with the effluent discharge chamber, and adjusting means for regulating the area of the upstream surface that is in fluid communication with the feed supply chamber, wherein the adjusting means comprise one or more moveable parts defining at least partly the feed supply chamber, in which reactor, during normal operation, no stagnant zone(s) occur in the fluid in the feed supply chamber.

2. A reactor according to claim 1, wherein, during normal operation, the area of the upstream surface that is in fluid communication with the feed supply chamber can be varied with a factor of at least 5, preferably at least 10, more preferable at least 20.

3. A reactor according to claim 1 or 2, wherein at least one of the moveable parts is a body which is slideably-arranged with respect to the catalyst bed, the body having a first surface directed to the catalyst bed, which first surface is capable of covering at least part of the upstream surface area, and a second surface defining at least partly the feed supply chamber.

4. A reactor according to any of claims 1 to 3, wherein, at the far end of the available upstream surface, the angle between the upstream surface and the surface defining the feed supply chamber is smaller than 70°, preferably smaller than 60°, more preferably smaller than 45°.

5. A reactor according to claim 4, wherein the surface defining the feed supply chamber at the near end of the available upstream surface is substantially parallel to the surface defining the feed supply chamber at the far end of the available upstream surface.

6. A reactor according to claim 4 or 5, wherein the catalyst bed is in the form of a hollow arrangement having a central longitudinal axis, preferably in the form of a hollow cylinder.

7. A reactor according to any of claims 1 to 6, wherein the feed supply chamber is equipped with means capable of swirling a fluid feed mixture in tangential direction.

8. A reactor according to claim 7, wherein the adjusting means comprises one moveable part, which is a disc comprising at least one opening, wherein, during normal operation, the disc is rotating parallel to the upstream surface.

9. A reactor according to claim 7 or 8, wherein the means capable of swirling a fluid feed mixture in tangential direction is a fan.

10. A process for the catalytic conversion of a fluid feed mixture which is capable of ignition or explosion, wherein the fluid feed mixture is contacted with a catalyst bed retained in the reactor according to any of claims 1 to 9.

11. A process according to claim 10 which is a process for the catalytic partial oxidation of a hydrocarbonaceous feedstock, which process comprises contacting a feed mixture comprising a hydrocarbonaceous feedstock and an oxygen-containing gas, in amounts giving an oxygen-to-carbon ratio in the range of from 0.3 to 0.8, with the catalyst bed at a temperature in the range of from 750 to 1500 °C, at a pressure in the range of from 2 to 100 bara.

12. A process according to claim 11, wherein the hydrocarbonaceous feedstock comprises light hydrocarbons, liquid hydrocarbons having an average carbon number of at least 6, oxygenates, or mixtures thereof.

13. A process according to claim 11 or 12, wherein the feedstock and the oxygen-containing gas are present in amounts giving an oxygen-to-carbon ratio in the range of from 0.45 to 0.75.

14. A process according to any of claims 11 to 13, wherein the feed mixture is contacted with the catalyst bed at a temperature in the range of from 800 to 1350 °C, preferably of from 850 to 1300 °C, more preferably of from 900 to 1250 °C.

15. A process according to any of claims 11 to 14, wherein the feed mixture is contacted with the catalyst bed at a pressure in the range of from 3 to 50 bara, preferably of from 5 to 30 bara.

16. A process according to any of claims 11 to 15, wherein the feed mixture is contacted with the catalyst bed at a maximum gas hourly space velocity in the range of from 50,000 to 10,000,000 Nl/kg/h, preferably of from 100,000 to 10,000,000 Nl/kg/h, more preferably of from 200,000 to 3,000,000 Nl/kg/h, especially of from 500,000 to 1,500,000 Nl/kg/h.

17. A process according to any of claims 11 to 16, wherein the feed mixture is contacted with the catalyst bed under substantially adiabatic conditions.

18. A process according to any of claims 11 to 17, wherein the catalyst comprises rhodium or iridium.

19. Transport means provided with the reactor according to any of claims 1 to 9.

C40/TS0743PD

TS 0743 EPC

A B S T R A C T

REACTOR

The invention relates to a reactor, suitable for the catalytic conversion of feed mixtures which are capable of explosion or ignition, comprising a feed supply chamber, an effluent discharge chamber, a catalyst bed having (1) an upstream surface and (2) a downstream surface which is in fluid communication with the effluent discharge chamber, and adjusting means for regulating the area of the upstream surface that is in fluid communication with the feed supply chamber, wherein the adjusting means comprise one or more moveable parts defining at least partly the feed supply chamber, in which reactor, during normal operation, no stagnant zone(s) occur in the fluid in the feed supply chamber, to the use of such a reactor, in particular a catalytic partial oxidation process, and to transport means provided with such a reactor.

C40/TS0743PD

TS 0743 EPC

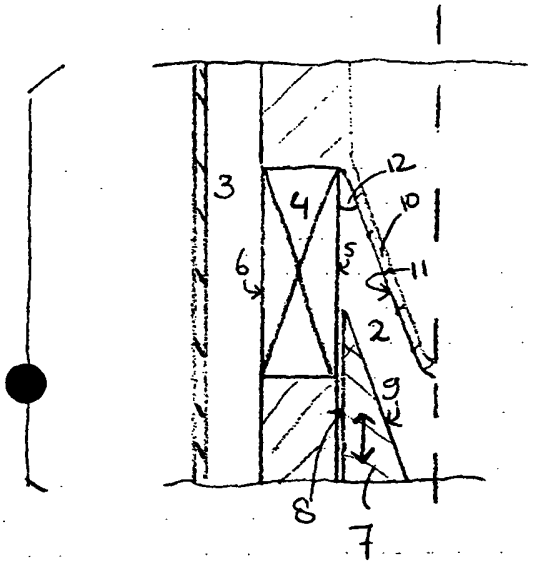

Figure 1a

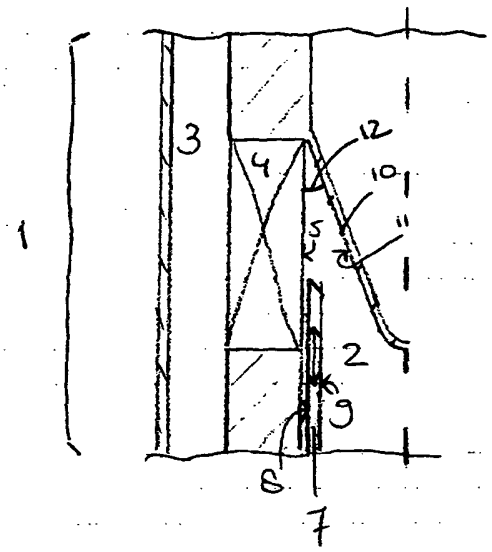

Figure 1b

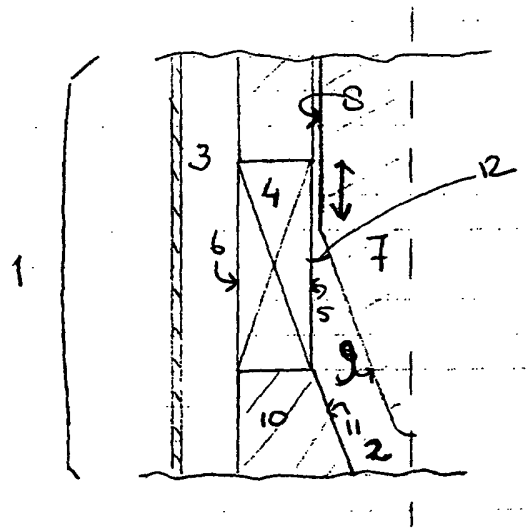

Figure 2a

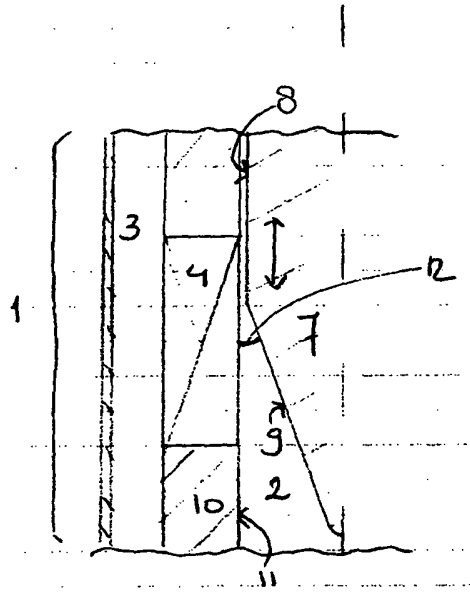

Figure 2b

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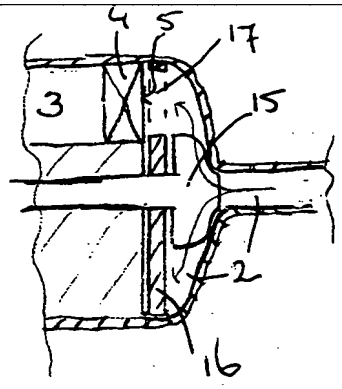

Figure 3a

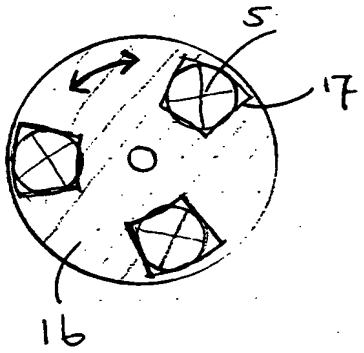

Figure 3b

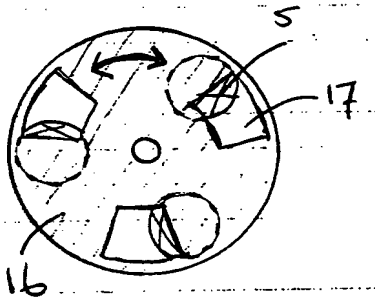

Figure 3c